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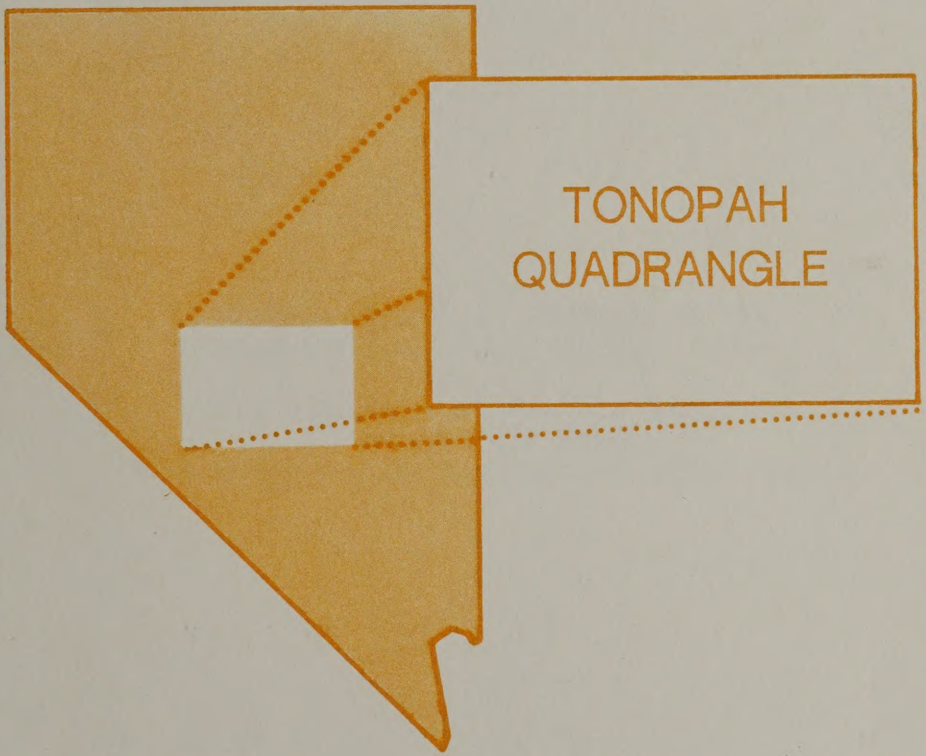
An Economic Evaluation of Selected Undiscovered Precious-Metal Deposits in the Tonopah Quadrangle, Nevada



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AN ECONOMIC EVALUATION OF SELECTED UNDISCOVERED PRECIOUS-METAL DEPOSITS IN THE TONOPAH QUADRANGLE, NEVADA

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Bureau of Mines
United States Department of the Interior

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EXECUTIVE SUMMARY

This is a study of the potential for the production of gold and silver from undiscovered resources in five types of mineral deposits-polymetallic vein, epithermal, polymetallic replacement, carbonate hosted and hot spring- in the Tonopah Quadrangle, Nevada. It was completed as part of a continuing effort by the Bureau of Mines (BOM) and the U.S. Geological Survey (USGS) to develop and present mineral resource and potential supply information in a form that is more useful to decisionmakers and analysts dealing with mineral-related policy and economic issues. An important part of this effort has been the development and application of techniques to provide quantitative (quantities and values) rather than qualitative (high, low) estimates of the undeveloped and undiscovered portions of the mineral endowment of an area. The study merges existing geologic knowledge of the region with the economics of mining and milling using current technologies. Finally, this work was completed as a pilot effort for a joint BOM/USGS analysis of a much broader range of mineral terranes and deposit types across the entire State of Idaho.

Results

Estimated undiscovered precious metal endowment,[1] for the five deposit types studied in the Tonopah Quadrangle, average 6.3 million troy ounces of gold and 203 million ounces of silver. Table 1 shows that at prices of $400/oz for gold and $8/oz for silver, potential production from these resources is estimated to average 1.8 million ounces of gold and 125 million ounces of silver. It is estimated (not shown in Table 1) that 40 percent of the potential gold and silver production at these prices will come from epithermal deposits. Prices of gold and silver as high as $1000 and $20 per ounce, respectively, could result in production of 3.6 million ounces of gold and 146 million ounces of silver from the resources remaining to be discovered. During the past decade, the price of gold (in 1987 constant dollars) has ranged from around $300 to $900 per ounce.

This report discusses the importance of considering the less likely, but yet, very real possibility that some very large and/or very rich deposits remain to be discovered in an area. This is especially important when policy decisions are being considered which could limit access to these mineral resources for many years into the future.

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[1] Resource endowment is defined as the total physical quantity of each metal contained in undiscovered deposits of the five types, subject to limits on minimum grade and minimum tonnage. Potential production refers to the portion of the endowment that may be recoverable under specified economic and technical conditions, assuming the area was fully explored.

In evaluating this broader range of possibilities (not shown in Table 1), the study finds there is 1 chance in 10 that the gold remaining to be discovered in the Tonopah Quadrangle is more than thirteen and one-half million troy ounces. At prices of $400 per ounce, there is a 10% chance that almost four and one-half million ounces of this remaining gold can be economically recovered, and, at $800 per ounce, this figure increases to seven and one-half million ounces. That amount of gold is almost twice the estimated[2] total gold production in the area from 1900 to 1984.

Table 1.-Cumulative Potential Average Production of Undiscovered Gold and Silver by Price Level, From Five Types of Deposits In the Tonopah Quadrangle of Nevada

Prices ($/tr. oz.)		Cumulative Potential Production (million troy ounces)	
Gold	Silver	Gold	Silver
200	4	0.7	85.6
400	8	1.8	124.5
600	12	2.8	138.8
800	16	3.3	143.7
1000	20	3.6	146.3

2/ See "Historical Production" section of this report.

ACKNOWLEDGMENTS

The authors acknowledge the work of Burt Gosling and Tom Camm of the Western Field Operations Center and Jim Lemons and R. Grey Christiansen of the Denver Minerals Availability Field Office of the Bureau of Mines who developed the mine and mill cost models used in this study. Don Singer, Barney Berger, Gretta Orris, and Dave Root of the U.S. Geological Survey assisted in providing and adapting the undiscovered resource data for use in the Bureau's Potential Supply Analysis System.

BACKGROUND

This study is an economic evaluation of the potential production of precious metals from five types of deposits - polymetallic vein, epithermal, polymetallic replacement, carbonate hosted and hot spring - in the Tonopah Quadrangle of Nevada. The study was completed as part of a continuing effort by the Bureau of Mines (BOM) and the U.S. Geological Survey (USGS) to develop and present mineral resource and potential supply information in a form that is more useful to decisionmakers and analysts dealing with mineral-related policy and economic issues. An important part of this effort has been the development and application of techniques to provide quantitative rather than qualitative (high, low) estimates of the undeveloped and undiscovered portions of the mineral endowment of an area.[3] An expanded version of the decision oriented analytic techniques described in this paper is currently being used to assist the Bureau of Land Management in meeting its land use decision making responsibilities for the White Mountains National Recreation Area and the Steese National Conservation Area of Alaska.

In applying these techniques to Tonopah, USGS assembled, evaluated, and interpreted geologic information to provide quantitative estimates of the undiscovered mineral resource characteristics of the area.[4],[5] These estimates are reported as probability distributions so the degree of uncertainty surrounding the estimates is explicitly and quantitatively expressed.

The Bureau uses this quantitative information in its Potential Supply Analysis System (PSAS)[6] to estimate the economic potential of these resources by evaluating the profitability of producing the expected types of mineral deposits with technically feasible mining and milling processes. The resulting quantitative estimates of potential mineral supplies serve as baseline information against which public policy and economic scenarios can be analyzed. The impact of changes in such policy and economic factors as land accessibility, environmental protection requirements, production technology, and taxes can then be measured in terms of their effect on the quantities and values of potentially recoverable mineral resources.

The current study of the Tonopah Quadrangle does not include analyses of public policy issues. The ongoing Statewide potential supply assessment of Idaho will include analyses of selected policy and economic issues.

3/ Work on these techniques is also underway in cooperation with the State of Alaska's Division of Geological and Geophysical Surveys.

4/ Singer and Ovenshine (1979).

5/ Cox and Singer (1986).

6/ See "Methodology" section for more complete description of PSAS.

METHODOLOGY

The Potential Supply Analysis System

The Potential Supply Analysis System (PSAS) used in this study is the Bureau of Mines' policy analysis system for estimating the quantity and value of minerals that might be produced in an area, from both undiscovered and known but undeveloped deposits, under various economic and policy conditions. The development of this system originated with the need to obtain better estimates of the mineral supply potential on public lands, and the mineral production consequences of federal land use decisions.[7] However, PSAS can be equally useful for investigating the effects of proposed environmental standards, policies directed at the critical and strategic mineral supply position of the United States, the benefits of new mining technologies (or research leading to new or lower cost mining technologies) and other areas of policy interest.

The system integrates three major analyses within a large-scale computer simulation. In the first component, geologists utilize existing and newly collected field data to estimate the potential for undiscovered mineral deposits and the important geologic characteristics of both the undiscovered and the known but undeveloped deposits in a particular geographic location. Second, the profitability (includes a 15% discounted cash flow rate of return on investment) of each of these mineral deposits is estimated for a range of possible mining and milling techniques and a range of assumptions about possible mineral market conditions. Those deposits found to be profitable are considered to be part of potential supply for the specified economic and market scenario. Third, in full scale analyses (not applied in this study of the Tonopah quadrangle), estimates are made of the number of jobs, annual incomes, and local and state tax revenues that could be generated by alternative mineral discovery, development, and production scenarios.[8]

A key element of a Potential Supply Analysis is the ability to incorporate uncertainty regarding geologic characteristics of the mineral resources which may be contained in an area. The degree of uncertainty about the type, quantity, and quality of these mineral resources will depend on the amount and quality of the geologic information available for the area under study. Geologists reflect their uncertainty by estimating a range of values that they believe may exist (along with estimated probabilities of existence), including the very rich but perhaps less likely possibilities. Using this information, the economic importance of the mineral potential of a region may be estimated, with the uncertainty reflected by a range of values - the greater the uncertainty, the wider the range.

7/ White, White, and Dillon (1987).
8/ Shantz and Maki, (1988).

This "base case" projection typically incorporates existing restrictions on lands or production methods, but may estimate potential with no restrictions. New estimates, reflecting the withdrawal of lands (e.g. Wilderness Areas, Scenic Rivers, etc.) or the adoption of new environmental standards (e.g. water quality requirements or transportation constraints), represent "policy cases." The differences between "policy" and "no policy" cases are measures of the mineral quantity and dollar costs of the proposed policies.

The Tonopah Study

This study of the Tonopah quadrangle assesses the undiscovered gold and silver that may be present in the five deposit types identified above, determines the potential for production of these metals from these deposit types, and estimates the economic values associated with any production that might occur.

The results reported here reflect: an assessment of the number, size, grade, and the depth of undiscovered mineral deposits based on the best available geologic knowledge; an evaluation of each deposit's economic feasibility using a set of mine and mill models reflecting current technologies; and the use of a monte carlo simulation model to allow the wide range of possibilities to be represented and evaluated.

This study makes several simplifying assumptions that will be relaxed in any subsequent statewide assessment. They are:

- All undiscovered deposits are assumed to be discovered in the first year of the analysis, and are evaluated from that point forward;
- Market prices and costs for any metals produced are assumed to remain constant throughout the life of a mine;
- This report focuses on precious metals, and does not report base metal production potential (although they were addressed in the analysis and helped determine mine profitability);
- The production potential for the area is estimated using five price scenarios for gold ranging from $200 to $1000 per troy ounce. Silver prices are equal to 1/50th of gold prices, and base metal prices are fixed at late-1987 levels; and
- There were assumed to be no capital or labor related production constraints, and no metal price changes resulting from new production.

HISTORICAL PRECIOUS METAL PRODUCTION

The State of Nevada

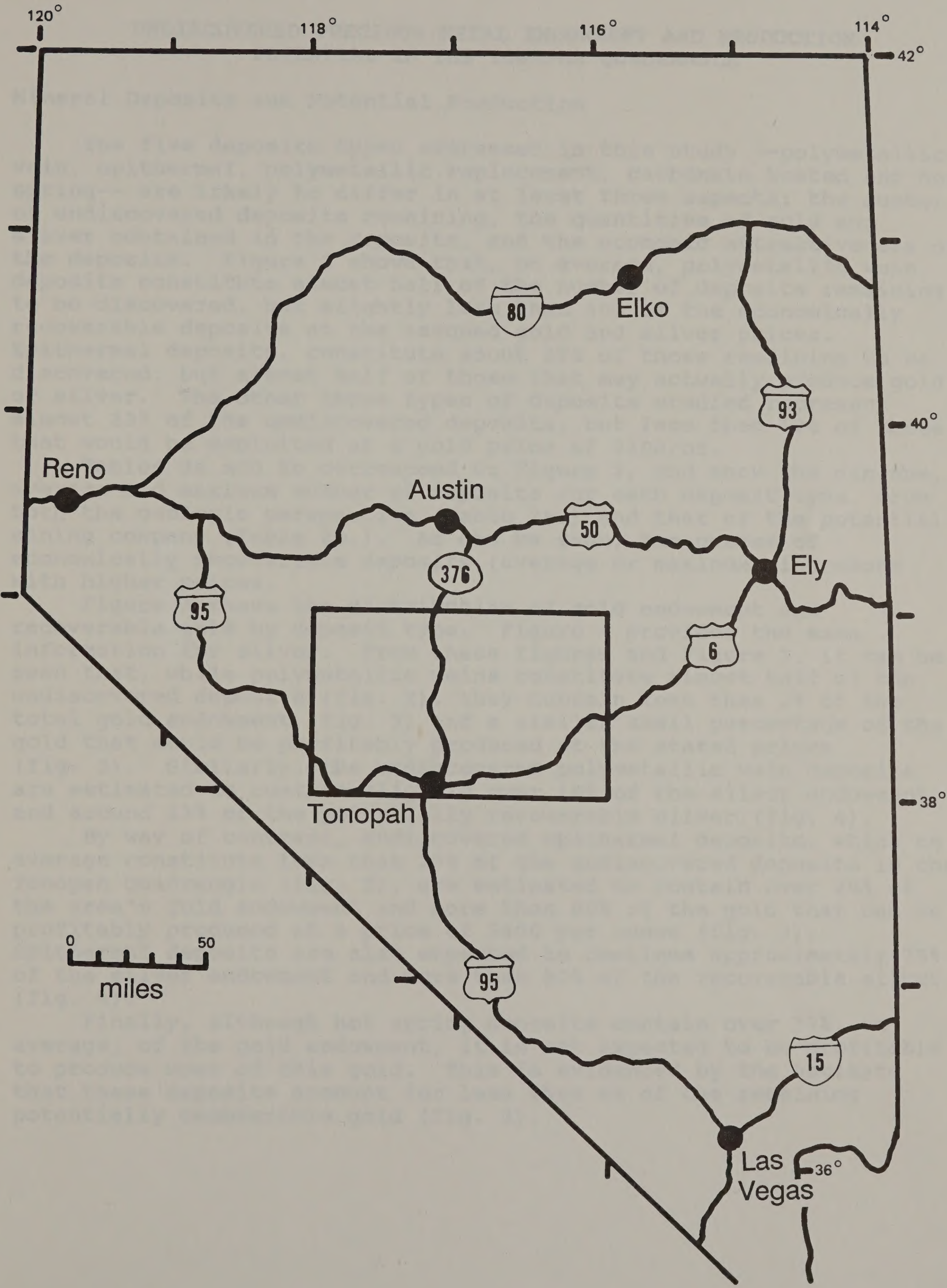
The gold mining industry in Nevada has experienced explosive growth in the 1980's resulting in the State accounting for 52 percent of total U.S. gold production in 1985. Annual gold production quadrupled and silver production doubled in Nevada between 1981 and 1986. The value of gold production in Nevada grew from $241.2 million in 1981 to $772.9 million in 1986. From 1981 to 1986, the boom in gold and silver mining created an estimated 1,956 new jobs in the mining industry and approximately 2,150 additional jobs in industries that sell to the mining companies and their employees. This added an estimated $165 million in annual personal earnings, directly and indirectly, to Nevada's economy.[9]

The Tonopah Quadrangle

Historically, the Tonopah Quadrangle has been one of the most productive regions in the State. The Tonopah Quadrangle is located in central Nevada (Figure 1), comprises approximately 19,000 sq. km. and lies between latitudes 38 and 39 degrees north and longitudes 116 and 118 degrees east. Major towns within the quadrangle include Gabbs, Manhattan, Round Mountain, and Tonopah. Gold mining has unquestionably played a long and significant role in the development of the region. Early activity, beginning in the late 1800s, was concentrated in the Bell (Cedar Mountain), Belmont, Mammoth (Lodi), Tybo, and Union districts. Important producing mining districts within the Tonopah quadrangle include the Manhattan, Round Mountain, and Tonopah districts. Gold production in the Tonopah quadrangle from 1900 through 1984 totaled approximately 3.7 million troy ounces.[10,11,12,13] Silver production in the Tonopah district alone - less than 10% of the quadrangle's area - from 1900 through 1961 was 174.1 million troy ounces.[12] While neither value represents total cumulative production from the Tonopah Quadrangle, they do provide useful reference points for the results of the following analysis.

9/ Swisko (1987).
10/ This number includes production from the following districts in the Tonopah Quadrangle: Bell (CedarMountain), Ellendale, Gold Hill, Jefferson Canyon, Mammoth (Lodi), Mangattan, Northumberland, Round Mountain, Tonopah, Tybo, and Union.
11/ Koschmann and Bergendahl (1986)
12/ Bonham and Garside (1979)
13/ Lowe, Raney, and Norberg (1985)

FIGURE 1. -THE TONOPAH QUADRANGLE, NEVADA



UNDISCOVERED PRECIOUS METAL ENDOWMENT AND PRODUCTION POTENTIAL IN THE TONOPAH QUADRANGLE

Mineral Deposits and Potential Production

The five deposits types addressed in this study --polymetallic vein, epithermal, polymetallic replacement, carbonate hosted and hot spring-- are likely to differ in at least three aspects: the number of undiscovered deposits remaining, the quantities of gold and silver contained in the deposits, and the economic attractiveness of the deposits. Figure 2 shows that, on average, polymetallic vein deposits constitute almost half of the number of deposits remaining to be discovered, but slightly less than 40% of the economically recoverable deposits at the assumed gold and silver prices. Epithermal deposits, constitute about 29% of those remaining to be discovered, but almost half of those that may actually produce gold or silver. The other three types of deposits studied represent almost 22% of the undiscovered deposits, but less than 12% of those that would be exploited at a gold price of $400/oz.

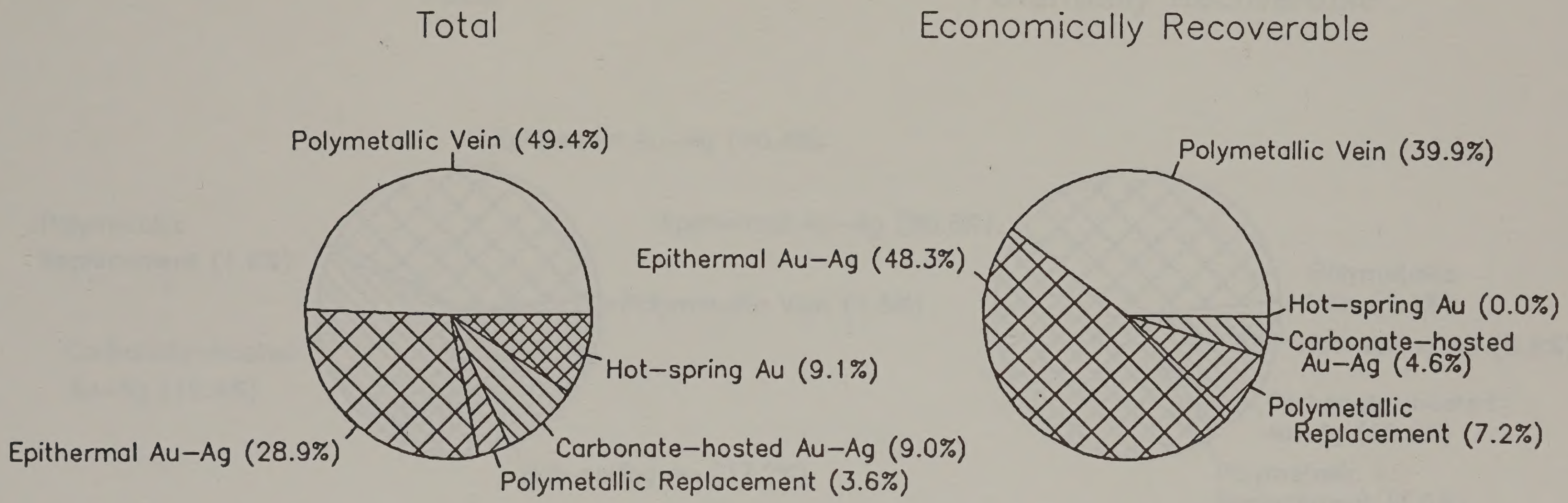
Tables 2a and 2b correspond to Figure 2, and show the minimum, average and maximum number of deposits for each deposit type, from both the geologic perspective (Table 2a.) and that of the potential mining company (Table 2b.). As can be seen, the number of economically recoverable deposits (average or maximum) increases with higher prices.

Figure 3 shows the distribution of gold endowment and recoverable gold by deposit type. Figure 4 provides the same information for silver. From these figures and Figure 2, it can be seen that, while polymetallic veins constitute almost half of the undiscovered deposits (fig. 2), they contain less than 2% of the total gold endowment (fig. 3) and a similar small percentage of the gold that could be profitably produced at the stated prices (fig. 3). Similarly, the undiscovered polymetallic vein deposits are estimated to contain slightly over 10% of the silver endowment and around 13% of the potentially recoverable silver (fig. 4).

By way of contrast, undiscovered epithermal deposits, which on average constitute less than 29% of the undiscovered deposits in the Tonopah Quadrangle (fig. 2), are estimated to contain over 40% of the area's gold endowment and more than 80% of the gold that can be profitably produced at a price of $400 per ounce (fig. 3). Epithermal deposits are also expected to continue approximately 75% of the silver endowment and more than 80% of the recoverable silver (fig. 4).

Finally, although hot spring deposits contain over 37%, on average, of the gold endowment, it is not expected to be profitable to produce most of this gold. This is evidenced by the estimate that these deposits account for less than 6% of the remaining potentially recoverable gold (fig. 3).

Figure 2. Number of Undiscovered Deposits: Distribution by Deposit Type for Total vs. Economically Recoverable



Average = 15

Average = 2.6
(Au = $400/oz and Ag = $8/oz)

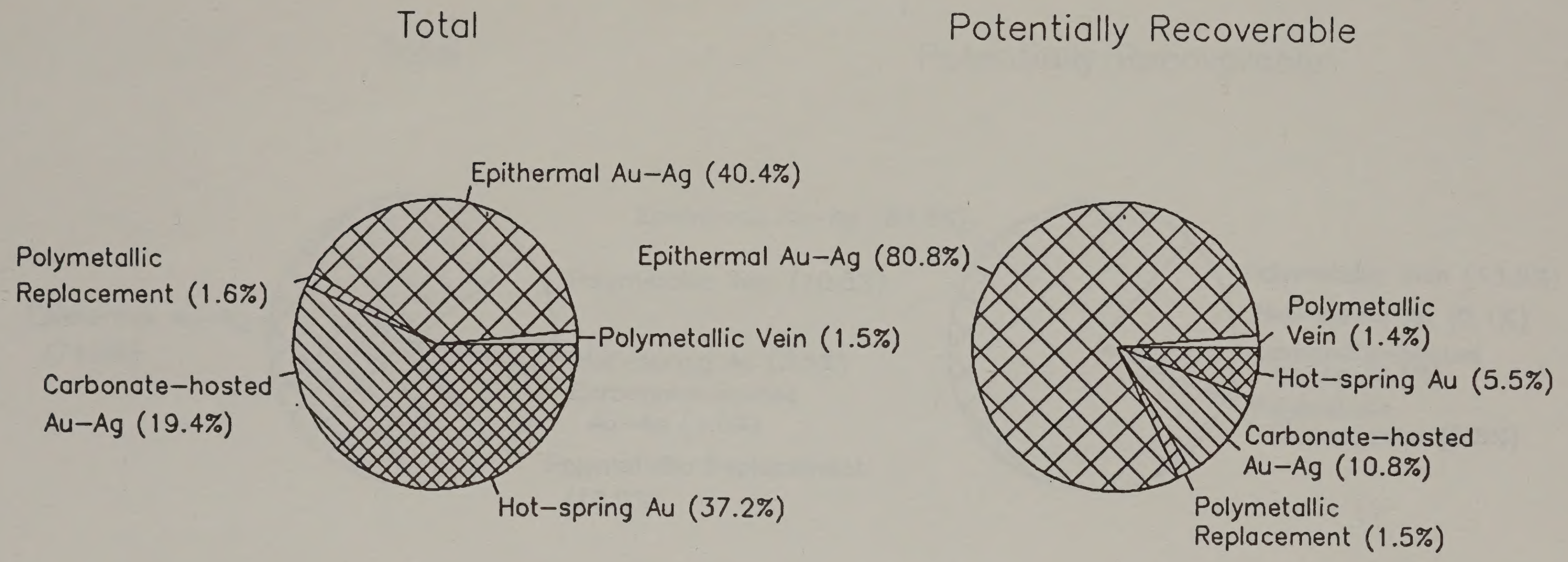


Figure 3. Undiscovered Deposits: Distribution by Deposit Type for Total Gold Endowment vs. Potentially Recoverable Gold

Average = 6.3 million oz

Average = 1.8 million oz
(Au = $400/oz)

Figure 4. Undiscovered Deposits: Distribution by Deposit Type for Total Silver Endowment vs. Potentially Recoverable Silver

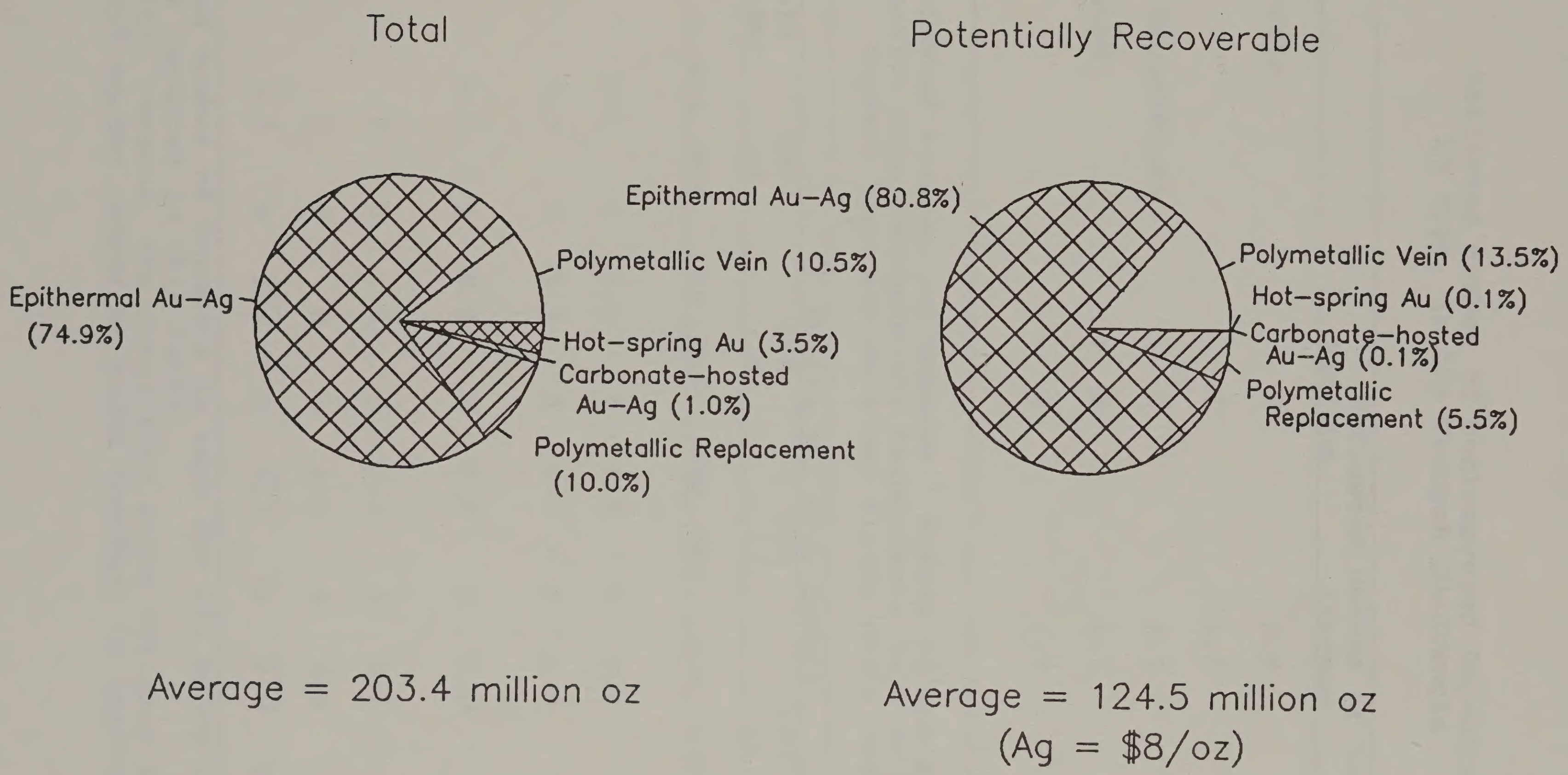


Table 2a.

Estimated Number of Undiscovered Deposits, by Type, in the Tonopah Quadrangle

	Estimated Number of Deposits		
Deposit Type	Minimum	Average	Maximum
Polymetallic Vein	2	6.9	13
Epithermal	1	4.1	11
Polymetallic Replacement	0	1.0	2
Carbonate-Hosted	0	1.3	4
Hot Spring	0	1.7	4

Table 2b. Estimated Average and Maximum [1] Number of Undiscovered Deposits with Economically Recoverable Gold or Silver by Deposit Type and Gold and Silver Price Levels

	Prices ($/ troy ounce)									
Gold	200		400		600		800		1000	
Silver	4		8		12		16		20	
Deposit Type	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.
Polymetallic Vein	0.4	3	1.0	4	1.6	6	2.0	7	2.4	7
Epithermal	0.3	4	1.3	6	2.1	8	2.6	8	3.0	8
Polymetallic Replacement	0.1	1	0.2	1	0.3	1	0.3	1	0.3	1
Carbonate Hosted	0	0	0	0	0.3	3	0.5	3	0.6	3
Hot Spring	0	0	0	0	0.2	2	0.4	3	0.6	3
Total [2]	0.8	6	2.6	8	4.4	12	5.8	15	6.9	16

1/ The minimum number of deposits is zero for all price levels and deposit types depicted in this table.

2/ For technical reasons, the quantities shown for each deposit type under the "Max" column cannot be added together to arrive at the "Total"

Uncertainty in Resource Assessments and Production Potential

Averages, while interesting as summary measures, tend to mask the uncertainty inherent in estimates of endowment and mineral production potential. Far more useful, to policy makers and the mineral industry, are estimates of the range of possibilities, and the likelihood of each of those possibilities. Such results may be developed using computer simulations, in which undiscovered deposit 'scenarios' are repeatedly created and evaluated. Each scenario contains various types, numbers, sizes and grade(s) of undiscovered mineral deposits; and uses standard economic evaluation methods to determine the potential for the production of their metals. Averages reported in this paper are the average outcomes of all scenarios, while the ranges reveal the variance of possible outcomes and their consequences.

Tables 3a and 4a expand upon the information in Figures 3 and 4, and show the range of quantities of gold and silver in the endowment, respectively, for deposits of each type.[14] The total undiscovered gold endowment is estimated to range from just over one million troy ounces at the 90-percent probability level to over 13.5 million at the 10-percent level. In other words, there is a 10% chance that the gold remaining in five types of undiscovered deposits is more than three and one-half times the estimated 3.7 million ounces of gold production from the Tonopah Quadrangle between 1900 and 1984.[15]

Polymetallic replacement deposits are less likely to exist in the Tonopah Quadrangle than other types. Carbonate hosted deposits are likely to be the least significant sources of silver resources contributing only slightly more than 2 million troy ounces on average, but with a 75% chance that no silver will be contained in these deposits. Total silver resources in the Quadrangle average more than 200 million ounces, with a 10% chance that more than 380 million ounces are contained in the five deposit types, and an equal chance than there are less than 12 million ounces.

---

[14] The likelihood of various quantities of resources is indicated by a cumulative probability distribution, shown in the column headings of each table. A "25%" in a column heading indicates that there is a 25% chance that the "true" value will be at least that given in the table (and a 75% chance that the "true" value will be smaller). In Table 3a, for example, there is a 75-percent chance that there are at least 455 thousand troy ounces of gold contained in epithermal deposits.

[15] See "Historical Production" section of this report.

Table 3a.

Undiscovered Gold Endowment by Deposit Type in the Tonopah Quadrangle (Thousands of Troy Ounces at indicated probability levels)

Deposit Type	Probability Level1/					
	.90	.75	.50	.25	.10	Average
Polymetallic Vein	0	2	8	24	103	90
Epithermal	126	455	1293	2838	5387	2541
Polymetallic Replacement	0	0	0	18	131	96
Carbonate-Hosted	81	205	585	1354	2660	1188
Hot Spring	0	1	354	1659	4711	2344
Total 2/	1031	1921	3745	6922	13573	6259

1/ The probability that the quantity is at least the given value.
2/ For technical reasons, except for the "average" column, the estimates shown for each of the five deposit types, under each probability column, cannot be added together to arrive at the "Total" shown for that probability column.

Table 4a.

Silver Endowment by Deposit Type in the Tonopah Quadrangle

(Thousands of Troy Ounces at indicated probability levels)

Deposit Type	Probability Level1/					
	.90	.75	.50	.25	.10	Average
Polymetallic Vein	841	2143	6480	18972	47247	20942
Epithermal	1106	5757	21451	79069	260785	153401
Polymetallic Replacement	0	0	0	10152	39537	19799
Carbonate-Hosted	0	0	0	0	2653	2148
Hot Spring	0	0	612	5652	19870	7138
Total 2/	12083	27882	67722	154036	381584	203428

1/ The probability that the quantity is at least the given value.

2/ For technical reasons, except for the "average" column, the estimates shown for each of the five deposit types, under each probability column, cannot be added together to arrive at the "Total" shown for that probability column.

Gold and Silver Potential Production and Economic Value

Potential Production

Tables 3b and 4b show the economically recoverable gold and silver at five price levels. At $200/oz gold and $4/oz silver it is estimated that there will be no recovery of either metal from hot spring deposits. On average, the proportion of the gold endowment contained in polymetallic vein deposits that is economically recoverable ranges from 27% at $200/oz to 33% at $1000/oz and, for silver, from around 69% to 89% at silver prices of $4/oz. and $20/oz., respectively.

Figures 5 and 6 graphically show three levels of certainty from the "total all deposits" sections of tables 3b and 4b. The three curves plot the minimum amounts of production expected at various price levels with the probabilities indicated. For example, Figure 5 shows that at $600/oz for gold, there is a 75% chance that the quantity of potentially recoverable gold is 373 thousand ounces or more. Also, there is a 25% chance that production will be between 373 thousand and 1.26 million ounces, a 25% chance that the quantity will be from 1.26 to 3.39 million ounces, and a 25% chance that production of gold will exceed 3.39 million ounces. Historical production of 3.7 million ounces of gold and 174 million ounces of silver are also plotted as a reference point on Figures 5 and 6, respectively.

Other statements that may be derived from these graphs (or the tables on which they are based) include: A gold price of approximately $700/oz would result in a one in four chance that future production potential would exceed past production (3.7 million troy ounces from 1900 to 1984); at all price levels, there is a 50% chance that virtually all recoverable gold will be obtained from one deposit type (epithermal); at historically high price levels, the production potential of gold is more sensitive than silver to further price increases; there is a chance (between 10% and 25%) that future silver production will exceed the 1900-1961 cumulative total for the Tonopah district; and there is a 50% chance that future silver production will be less than 37 million ounces, even at prices as high as $20/oz.

Finally, it is important to note that Tables 3b and 4b show a wide range in the possible quantities of potentially economically recoverable gold and silver resources from deposits waiting to be discovered in the Tonopah Quadrangle. Of particular importance, however, is the fact that this range includes the possibility that substantial resources may yet be produced from the area, depending upon the prevailing prices. Indeed, it is the less likely but very real possibility of finding those profitable larger and/or higher-graded deposits that provides the motivation for mineral companies to invest their financial resources in exploration. These investments, in turn, generate jobs, income and revenues for the hosting State and the Nation. It is important, therefore, that estimates of

Table 3b. Potentially Economically Recoverable Gold in the Tonopah Quadrangle, by Deposit Type, Price and Probability (Thousands of Troy Ounces at indicated probability levels)

Deposit Type	Probability Level 1/					
	.90	.75	.50	.25	.10	Average
Polymetallic Vein						
$200/oz.	0	0	0	0	9	24
400/oz.	0	0	0	3	18	26
600/oz.	0	0	0	6	25	28
800/oz.	0	0	1	7	29	29
1000/oz.	0	0	1	8	32	30
Epithermal						
$200/oz.	0	0	0	0	1351	654
400/oz.	0	0	341	1657	3810	1480
600/oz.	0	159	716	2204	4243	1884
800/oz.	30	266	894	2338	4419	2023
1000/oz.	96	319	1004	2370	4477	2082
Polymetallic Replacement						
$200/oz.	0	0	0	0	0	18
400/oz.	0	0	0	0	15	28
600/oz.	0	0	0	0	38	36
800/oz.	0	0	0	0	51	39
1000/oz.	0	0	0	0	56	39
Carbonate-Hosted						
$200/oz.	0	0	0	0	0	51
400/oz.	0	0	0	0	186	197
600/oz.	0	0	0	123	1055	351
800/oz.	0	0	0	420	1385	468
1000/oz.	0	0	69	584	1552	549
Hot Spring						
$200/oz.	0	0	0	0	0	0
400/oz.	0	0	0	0	0	100
600/oz.	0	0	0	0	490	468
800/oz.	0	0	0	215	1589	765
1000/oz.	0	0	0	383	2014	940
Total All Deposits 2/						
$200/oz.	0	0	0	253	1531	747
400/oz.	0	22	558	2098	4467	1831
600/oz.	79	373	1263	3390	6354	2767
800/oz.	238	703	1726	3902	7524	3324
1000/oz.	340	899	2013	4245	7984	3640

1/ The probability that the quantity is at least the value shown.

2/ For technical reasons, except for the "average" column, the quantities shown for each of the price levels under each deposit type and under each probability column, cannot be added together to arrive at the "Total All Deposits" shown for that price level and probability column.

Table 4b. Potentially Economically Recoverable Silver in the Tonopah Quadrangle, by Deposit Type, Price and Probability (Thousands of Troy Ounces at indicated probability levels)

Deposit Type	Probability Level 1/					
	.90	.75	.50	.25	.10	Average
Polymetallic Vein						
$ 4/oz.	0	0	0	2545	19806	14441
8/oz.	0	0	1255	9040	21934	16838
12/oz.	0	289	2351	10628	23444	17755
16/oz.	0	764	2960	11547	24423	18375
20/oz.	87	975	3567	11800	26281	18674
Epithermal						
$ 4/oz.	0	0	0	0	22850	66691
8/oz.	0	0	3356	38237	155269	100567
12/oz.	0	1028	11489	60774	187844	111540
16/oz.	72	1999	15116	66027	198731	114644
20/oz.	351	3359	16069	67270	200236	116303
Polymetallic Replacement						
$ 4/oz.	0	0	0	0	389	4473
8/oz.	0	0	0	0	12607	6822
12/oz.	0	0	0	0	17873	8613
16/oz.	0	0	0	1689	19706	9057
20/oz.	0	0	0	2514	20100	9257
Carbonate-Hosted						
$ 4/oz.	0	0	0	0	0	2
8/oz.	0	0	0	0	0	97
12/oz.	0	0	0	0	0	249
16/oz.	0	0	0	0	0	321
20/oz.	0	0	0	0	124	369
Hot Spring						
$ 4/oz.	0	0	0	0	0	0
8/oz.	0	0	0	0	0	127
12/oz.	0	0	0	0	400	662
16/oz.	0	0	0	0	2450	1317
20/oz.	0	0	0	566	3547	1661
Total All Deposits 2/						
$ 4/oz.	0	0	665	18180	75287	85605
8/oz.	122	3158	17597	71484	211709	124451
12/oz.	2601	9305	29224	94830	246295	138818
16/oz.	4194	12229	35374	99734	253717	143713
20/oz.	5506	14401	36958	101060	261574	146264

1/ The probability that the quantity is at least the value shown.

2/ For technical reasons, except for the "average" column, the quantities shown for each of the price levels under each deposit type and under each probability column, cannot be added together to arrive at the "Total All Deposits" shown for that price level and probability column.

Figure 5. Gold Production Potential - Tonopah Quadrangle

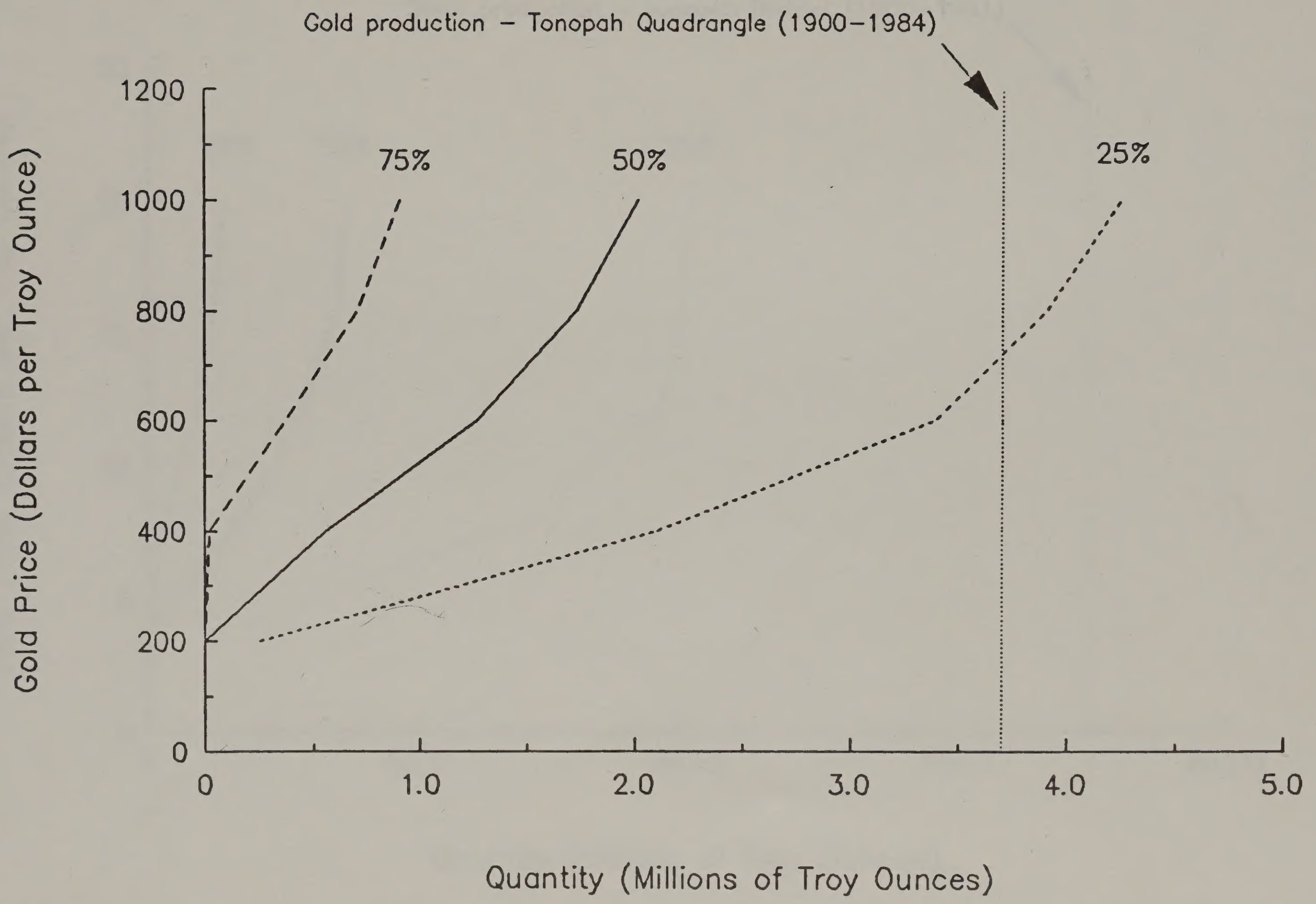
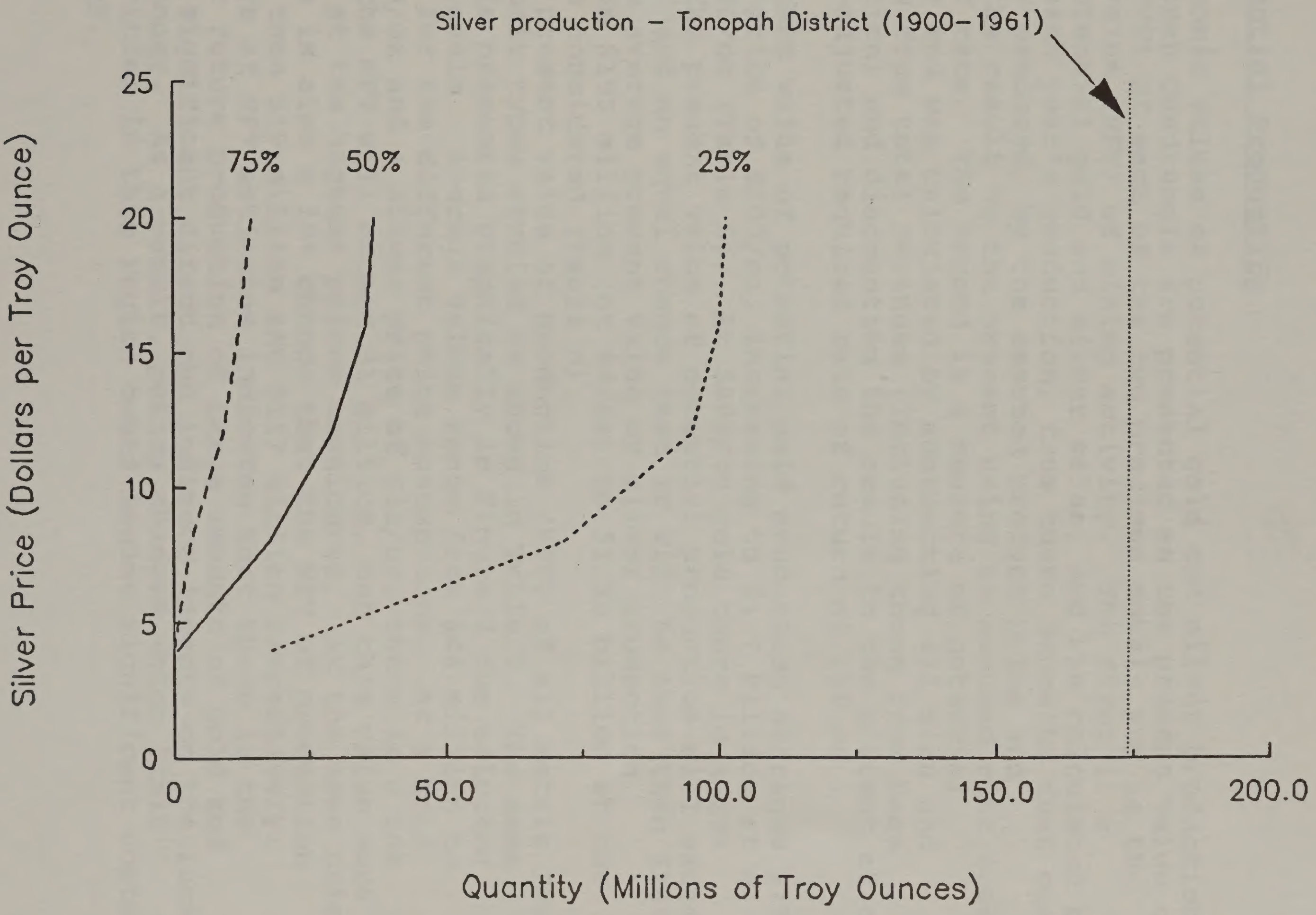


Figure 6. Silver Production Potential – Tonopah Quadrangle



the impacts of policies which affect access to these minerals or that increase the costs of their production be based on the full range of potential supplies. Estimates of impacts based upon the "average" or "most likely" values may result in significantly underestimating the potential costs to the Nation of such decisions.

Value of Potential Production

The economic values of potential gold and silver production from the Tonopah Quadrangle are presented as the present value of production (PVP) of each of the two precious metals and as the net present value (NPV) of mining activity. The first is a measure of potential gold and silver sales, and was calculated by multiplying each year's production, from those deposits that can be profitably produced, by the assumed product price and discounting the result to the present using an assumed risk free 7.5% discount rate. The second is a measure of potential profitability and was calculated by subtracting all mine and milling costs from total revenues (including those from base metal production) and discounting the result to the present at an assumed risk-adjusted required rate of return of 15% on investment.

The present value of potential gold production averages $73 million at a price of $200/oz, increasing to $1.7 billion at a price of $1000/oz (Table 5). At $800/oz gold there is a 10% chance that the present value of potential production will exceed $2.8 billion, and an equal chance that it will be less than $108 million. The average present value of silver production increases from $153 million (at $4/oz) to $1.35 billion at the highest price considered (Table 6).

The net present value of production (NPV) of all metals from the five deposit types studied is shown in Table 7. The same information is presented graphically in Figure 7 for selected probability levels. Average values range from $46 million to $1.2 billion for the different price assumptions. At a gold price of $600/oz and a silver price of $12/oz, there is a 10% chance that the NPV will exceed $1 billion, but this value more than doubles at the highest prices considered. At the same price levels, there is also a 10% chance that the NPV of production will be less than $19 million and $117 million respectively.

The range of NPV estimates indicates that there is the potential for future production of large amounts of gold and silver, with significant direct and indirect impacts on the local and state economy. As a result, policy changes which limit mineral activities in this region could impose significant costs on its economy.

Table 5. Present Value of Potential Gold Production in the Tonopah Quadrangle, by Price and Probability (Millions of 1986 Dollars)

Gold Price ($/ troy ounce)	Probability Level 1/ .90	.75	.50	.25	.10	Average
200	0	0	0	27	177	73
400	0	5	129	436	955	355
600	30	129	416	997	1861	789
800	108	313	739	1589	2830	1253
1000	199	502	1042	2118	3688	1706

1/ The probability that the present value is at least the value shown.

Table 6. Present Value of Potential Silver Production in the Tonopah Quadrangle, by Price and Probability (Millions of 1986 Dollars)

Silver Price ($/ troy ounce)	Probability Level 1/ .90	.75	.50	.25	.10	Average
4	0	0	2	45	156	153
8	1	16	83	312	842	456
12	19	66	197	607	1463	768
16	41	115	317	855	1959	1062
20	66	170	412	1104	2494	1353

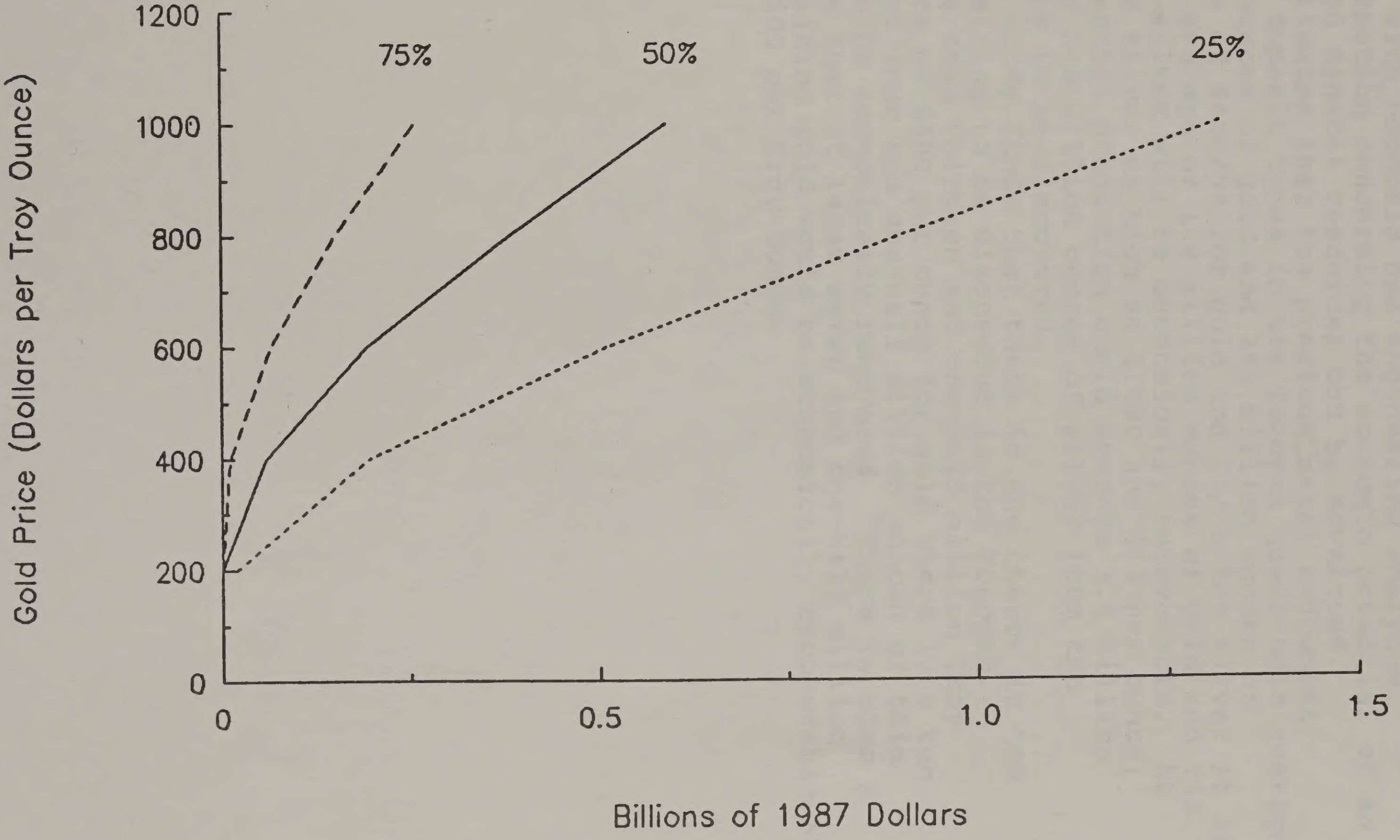
1/ The probability that the present value is at least the value shown.

Table 7. Net Present Value of Production of All Metals in Undiscovered Deposits in the Tonopah Quadrangle, by Price and Probability (Millions of 1986 Dollars)

Prices ($/troy Ounce)		Probability Level 1/					
Gold	Silver	.90	.75	.50	.25	.10	Average
200	4	0	0	1	20	83	46
400	8	0	11	58	193	506	238
600	12	19	64	190	510	1035	510
800	16	63	149	379	899	1659	836
1000	20	117	255	586	1318	2288	1186

1/ The probability that the net present value is at least the value shown.

Figure 7. Metal Production Potential – Tonopah Quadrangle
Net Present Value of Production



CONCLUSION

This study has shown that by using techniques which merge geologic analysis with economic and engineering analyses, quantitative information concerning the economic potential of an area's undiscovered mineral resources can be developed.

The study estimates that the precious metal endowment contained in five deposit types in the Tonopah Quadrangle average 6.3 million troy ounces of gold and 203 million ounces of silver. At prices of $400/oz for gold and $8/oz for silver it is estimated that an average of 1.8 million ounces of gold and 125 million ounces of silver will be economically recoverable. At prices of gold and silver as high as $1000 and $20 per ounce, respectively, potential production could average 3.6 million ounces of gold and 146 million ounces of silver from the endowment remaining to be discovered.

Finally, the study finds that there is one chance in ten that the gold remaining to be discovered in the Tonopah Quadrangle is more than thirteen and one-half million troy ounces. At a price of $400 per ounce for gold there is a ten percent chance that four and one-half million ounces of this remaining gold can be economically recovered. There is also a ten percent chance that at least seven and one-half million ounces of the remaining gold would be economically recoverable at a gold price of $800 per troy ounce.

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